ZONOLITE ATTIC INSULATION REPORT

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This report was prepared jointly by Dr. William Longo and Richard Hatfield of MAS.

I, William E. Longo, am an expert in the fields of microscopy, materials science and engineering, and asbestos analysis and evaluation. I have a Master of Science degree in Engineering and a Doctorate of Philosophy degree in Materials Science and Engineering, both from the University of Florida. I am currently the president of Materials Analytical Services, Inc., a company specializing in materials characterization.

Throughout my career, I have analyzed asbestos bulk, air and settled dust samples for both private clients and government agencies. I have also consulted for the EPA on its protocol for asbestos sampling at Superfund sites and the dust analysis protocol. I have assisted NATO in the analysis of materials from school buildings located over seas and the Berlin Wall for the presence of asbestos. I have analyzed asbestos samples for governmental and private entities. I have also analyzed asbestos samples for corporations that formerly manufactured asbestos-containing products, including W.R. Grace.

I have authored and co-authored numerous articles regarding asbestos sampling and testing techniques. I have served on the Peer Review Group Committee for the EPA, a group responsible for guiding EPA's research involving various asbestos issues in occupied buildings. Additionally, I was invited by the EPA along with others, to help develop its protocol for taking and analyzing settled dust samples during some of its research studies. I am also a member of the American Society of Testing Materials (ASTM Subcommittee for asbestos sampling and analysis). My contribution to this particular subcommittee involved such things as being the primary author of the ASTM method D-5755-95 entitled "Micro-Vacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Concentration".

I am an expert in the field of materials characterization, the use of materials for specific applications, and the ability to determine their physical and chemical properties using recognized testing procedures. I will testify about testing protocols routinely used for materials characterization and analyzing asbestos samples, including sample preparation and fiber counting. A copy of my curriculum vitae is included with this statement and is incorporated by reference. [Attachment A]

I will also discuss the standard and accepted scientific methods and techniques used for identifying and quantifying asbestos in various samples such as air, dust and bulk. I will testify about the different forms of asbestos, including their morphology and mineralogy. I will discuss in particular the morphology and mineralogy of the Libby Amphibole Asbestos found as a contaminant in Grace's Zonolite Attic Insulation (ZAI) product. I will discuss the nature of ZAI and the results of testing of ZAI by my laboratory using standard accepted scientific methods and techniques for analysis. I will discuss the testing of ZAI preformed by Grace and will compare its results with results of testing by my laboratory.

My charge for testimony and deposition testimony is $275 an hour. I have provided expert testimony in asbestos property damage cases in both federal and state court. A list of prior testimony will be provided in the future.

I, Richard L. Hatfield, am an expert in the field of asbestos in buildings. I obtained Bachelor of Science degrees in Experimental Statistics and Geology from North Carolina State University, and began my career in asbestos consultation in 1979 as a Technical Field Advisor to EPA's "Asbestos in Schools" Program. I was appointed as an expert advisor to the EPA's negotiated rule making committee to promulgate new regulations for asbestos in schools pursuant to AHERA (Asbestos Hazards Emergency Response Act). After completing the EPA's "Asbestos in Schools" program in 1979, I developed methods for solving asbestos problems in buildings for Law Engineering and Environmental. In 1982 I was recruited by McCrone Environmental Services to develop and manage its Atlanta based company, and served as Director of Services for five years. My work at McCrone involved the management of laboratory microscopy, field testing and field evaluations of asbestos in buildings. During this time, McCrone was recognized as a leader in the specialized fields of light and electron microscopy. While there, I utilized various methods of microscopy and chemical analysis to solve asbestos-related problems. In December 1987, I returned to Law Engineering where I assessed asbestos problems in buildings and worked extensively with the laboratory of Materials Analytical Services. I joined Materials Analytical Services in August 1996, where I apply my knowledge of asbestos-containing materials as Senior Consultant.

During the years I have dealt with asbestos-related problems, I have instructed over fifty (50) courses and seminars on asbestos in buildings. I have developed protocols for the collection and analysis of settled asbestos dust in buildings, and consulted with the EPA and the American Society for Testing and Materials (ASTM) in establishing guidelines for these protocols. These protocols have been accepted by both the scientific and the legal community.

As a consultant, I have advised hundreds of public and private building owners concerning the appropriate action to take regarding the disposition of asbestos in their properties. As part of my consulting services I have acquired extensive experience in the field of identifying products by visual and microscopic examination of the materials and their components, and in the field of collection and analysis of the amount and frequency of asbestos released from asbestos-containing buildings materials. My expert qualifications and training are set forth more fully in the attached curriculum vitae, which is incorporated by reference [Attachment B].

I have provided expert testimony in numerous asbestos property damage cases in both federal and state court. A list of prior testimony will be provided in the future Additionally, my charge for trial and deposition testimony is $225.00 per hour.

I have participated in demonstrations, reviewed experiments and performed tests

involving asbestos-containing materials, in which either the material or its residue was disturbed in a manner similar to that which would occur during routine building operations and maintenance activities. This disturbance resulted in the release of varying significant levels of airborne asbestos-containing dust. I have participated in similar studies involving ZAI. Such tests indicate that persons engaged in cleaning, repairs, renovations, or removals that disturb ZAI or dust and debris from ZAI will be exposed to significantly elevated and potentially dangerous levels of asbestos fibers.

I am an expert in the field of asbestos materials characterization, the use of asbestos materials for specific applications, and the ability to determine their physical and chemical properties using recognized testing procedures. I will testify about testing protocols routinely used for materials characterization and analyzing asbestos samples, including sample preparation and fiber counting.

I will also discuss the standard and accepted scientific methods and techniques used for identifying and quantifying asbestos. I will testify about the different forms of asbestos, including their morphology and mineralogy. I will discuss in particular the morphology and mineralogy of the Libby Amphibole Asbestos found as a contaminant in Grace's Zonolite Attic Insulation (ZAI) product. I will discuss the nature of ZAI and how it relates to testing by my laboratory using standard accepted scientific methods and techniques for analysis.

STANDARD TYPES OF MICROSCOPIC EQUIPMENT USED TO IDENTIFY & QUANTIFY ASBESTOS

In general, asbestos refers to a family of naturally occurring fibrous silicate minerals. As discussed below, Grace's ZAI product was contaminated with varying amounts of asbestos in the tremolite series of minerals. In its fibrous form, asbestos is made up of parallel strands of fibers that will separate into individual respirable sized fibers that are invisible to the naked eye. Depending on the asbestos mineral, individual asbestos can be as small as 0.025 microns in diameter. Because of its size and mineralogy, identification and quantification of asbestos requires the use of sophisticated microscopic equipment operated by highly trained analysts. The types of microscopes used to analyze and identify asbestos fibers fall into two categories, light microscopes and electron microscopes. Light microscopes include the polarized light microscope (PLM) and phase contrast microscope (PCM).

The PLM is mainly used to analyze bulk samples in order to determine the presence and amount of asbestos in materials, such as ZAI. The PLM technique allows the analyst to distinguish between asbestos and other types of fibers through the use of polarizing lenses, rotation of the samples and various other optical techniques. By knowing the optical properties of various types of fibers, the analyst can distinguish between asbestos and non-asbestos fibers, and can identify the type of asbestos. Ordinary PLM allows an analysis to detect asbestos in a bulk sample in amounts at 0.1% by weight and above depending on the type of material that contains the asbestos fibers.

The PCM is a light microscope equipped with a special light source that allows the analyst to resolve fibers easier. The PCM is the standard equipment used to analyze airborne fiber levels in an occupational setting for compliance purposes under the Occupational Safety and Health Administration (OSHA) regulation. Because the analysis is performed at a magnification of 400X, only fibers/bundles with a minimum diameter of 0.25 microns and a minimum length of 5.0 microns are counted for regulation purposes in occupational settings. The PCM method does not allow the analyst to distinguish between asbestos and non-asbestos fibers. Because the PCM does not allow the analyst to distinguish between asbestos and non-asbestos fibers, all fibers are presumed to be asbestos under the OSHA regulation.

There are two main types of electron microscopes available for asbestos analysis, the transmission electron microscope (TEM) and the scanning electron microscope (SEM). Because the size of electrons is much smaller than the wavelength of light, both types of electron microscopes have resolution capabilities allowing the analyst to resolve individual asbestos fibers/bundles much smaller than 0.25 microns in diameter. In most instances, electron microscopes allow the analyst to identify the various types of asbestos through their chemical composition. The analytical SEM is fitted with an energy dispersive x-ray analysis (EDXA) system that can provide information about the elemental composition of a particle or fiber. The analytical transmission electron microscope (TEM) is also equipped with an EDXA system for micro-chemical analysis as well as electron diffraction that provides information about a particle's unique crystal structure in the same manner as powdered x-ray diffraction but on a smaller scale. Individual fibers including those of the smallest asbestos fibers (0.02 µm in diameter) can be studied with TEM.

Our experience has shown that the use of a transmission electron microscope is the preferred way to analyze asbestos air and dust samples because it allows the analyst to detect and identify long as well as short fibers that are very thin (less than approximately 0.25 micrometers wide). Because of their limited resolution, light microscopes are unable to detect the long fibers (greater then 5.0 microns) with a diameter less than 0.25 microns.

ASBESTOS FIBERS DEFINED

From the analyst's point of view, an asbestos fiber is defined by the counting method being used. For airborne fibers counted on filters, EPA under the Asbestos Hazards Emergency Response Act (AHERA) counting rules, defines a fiber as having a length of at least 0.5 µm long, with a 5:1 or greater aspect ratio, and substantially parallel sides. The International Standards Organization (ISO) and ASTM TEM air methods also use the minimum 0.5 µm length with a 5:1 aspect ratio definition in their work. Under section 3.22 of the ISO 10312 counting rules, a fiber (listed as the British spelling 'fibre') is an elongated particle that has parallel or stepped sides.

For airborne fibers counted on filters in an occupational setting, OSHA uses a definition of a fiber that is at least 5 µm long with an aspect ratio (length to width) of at least 3:1. This 5 micron length limitation was not related to toxicity. Instead, the lower length limitation of 5 microns in OSHA's counting rule was based on the limitations of the light microscope, which OSHA had approved for use in analyzing air samples in occupational settings. Grace's chief microscopist, Julie Yang recognizes this limitation in a 1980 document:

> As to the lower limit of fiber lengths, it is 5 µm presently because it is close to the optical microscope reliable resolution limit, the equipment (up to 430x magnification) which OSHA and MESA approved for counting. However, it does not mean that fibers of <5 µm in length are not hazardous. If the transmission electron microscope (1,000 – 50,000x magnification generally) becomes more popular in use and lower in cost, the limit may be lowered to 1µm range since many recent publications indicated that the smaller asbestos fibers are also potent carcinogens.
>
> February 15, 1980 memo from Yang to Duecker

METHODS OF ANALYSIS OF ASBESTOS

We personally, and with the aid of our staff, have analyzed tens of thousands of asbestos samples of all types, including bulk samples, micro-vacuum dust samples, air samples, water samples and human lung tissue samples. We will explain the methodology employed in analyzing the various types of samples. As discussed below, the types of testing and the nature of the material dictates the methods used for analysis in any given situation. Where the PCM is used, the NIOSH 7400 method is the standard method used in occupational settings and can be supplemented with TEM analysis using NIOSH 7402, "Asbestos Fibers by Transmission Electron Microscopy (TEM), "NIOSH Pub. 94 - 113 (1994). Currently, there are no PCM methods for non-occupational settings. We used the NIOSH 7400 method to analyze airborne asbestos samples in our investigations of ZAI.

In non-occupational settings, there are a number of accepted methods for the analysis of air samples by TEM, which provides identification of the asbestos fibers, and provides additional information about sizes of the asbestos fibers. The Yamate method is probably the most comprehensive and widely accepted method for analysis of airborne asbestos by TEM. Mr. George Yamate published a method for the TEM analysis of air samples for EPA in 1984, which became one of the cornerstones for all TEM air sample analysis, including the EPA AHERA method and NIOSH 7402 method. The Yamate procedure is the process of taking an air sample that was collected with either a mixed cellulose ester (MCE) or a polycarbonate (PC) filter, and then preparing that filter for examination in the TEM. Asbestos fibers are defined as a fibrous structure with the appropriate chemistry and crystalline makeup that has an aspect ratio (length to width) of at least 3 to 1 and can be any length. A known area of the filter is examined in the TEM and the number of asbestos structures in that known area of the filter is counted and recorded.

Since the Yamate method was published, EPA's AHERA regulation has redefined asbestos fibers for TEM analysis to include fibers longer than .05 microns and having an aspect ratio of 5:1. This definition has been accepted and utilized in all of the TEM methods developed since AHERA. This current definition is easily adapted to previous TEM methods, such as the Yamate method. Therefore, we utilize the current EPA definition for the Yamate protocol. This is just a slight variation of original counting rules in the Yamate protocol. Defining the aspect ratio as 5:1 rather than 3:1 and counting only fibers greater then 0.5 microns in length is a more conservative definition for asbestos fibers while remaining consistent with EPA. As stated above, the Yamate TEM method with the current counting rules was one of the protocols used for our ZAI studies in addition to the NIOSH 7400 method (PCM).

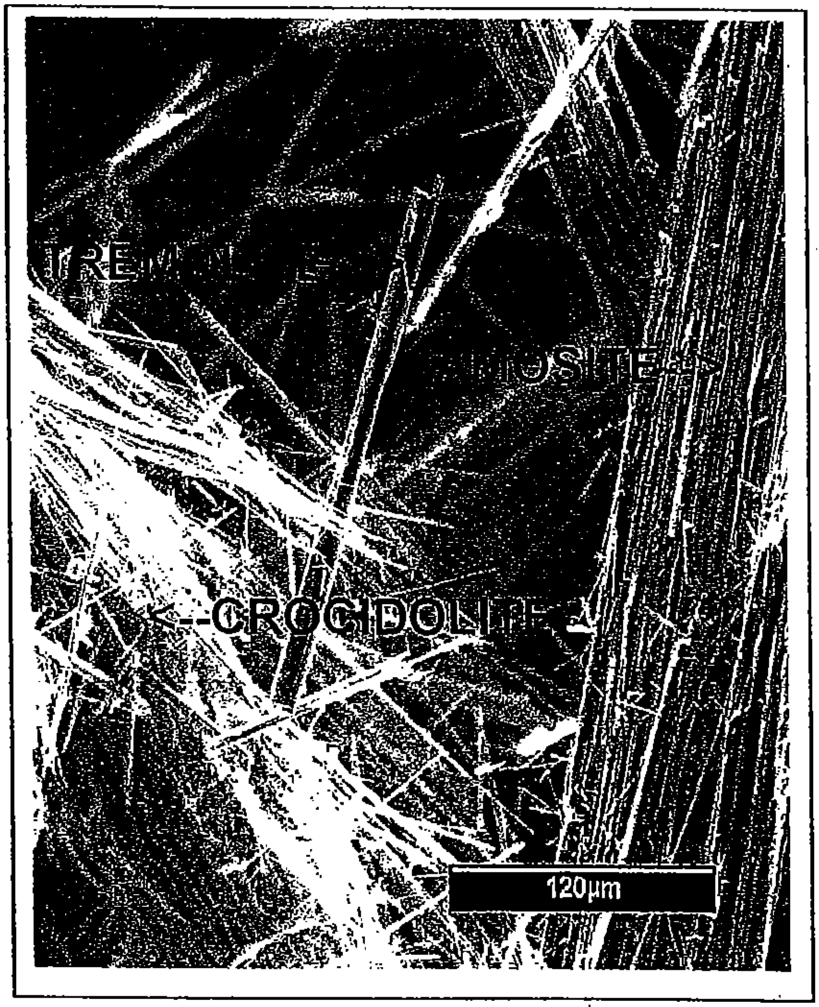
FORMS OF ASBESTOS – SERPENTINE AND AMPHIBOLE

There are two major forms of asbestos, Serpentine and Amphibole. Chrysotile asbestos, in the serpentine family, was the form of asbestos most widely used in commercial products in North America. The morphology of chrysotile is generally found to be wavy and somewhat flexible with a very high tensile strength. It tends to be less persistent in an acid or basic solution and can be dissolved over time.

The vast majority of chrysotile used in commercial products was mined in Quebec, Canada. Because of the extensive use of chrysotile in commercial products, there is a very low background level of chrysotile asbestos in the air in the environment. This background level in the environment has been reported by EPA to be in the range of 0.000001(rural) to 0.00001 (urban) ` asbestos structures per cc. (HEI-AR Asbestos in Public and Commercial Buildings Report 1991 p. 1-4, 5). Amphibole asbestos

(amosite/crocidolite) was far less used. As a consequence, it is unusual to find background levels of amphibole in the air.

Amphibole forms of asbestos include the tremolite/actinolite series of asbestos found in ZAI (which will be discussed in more detail below), anthophyllite, crocidolite and amosite. These forms of asbestos are marked by their needle-like appearance and are more persistent, less affected by acid or base solutions and less likely to dissolve over time.



LIBBY AMPHIBOLE ASBESTOS FOUND IN ZAI

The vermiculite used in Grace's ZAI product was mined at Grace's Vermiculite mine in Libby, Montana. Notably, this mine contains significant amounts of fibrous amphibole asbestos in the tremolite series of asbestos, as well as anthophyllite. Libby ore content varied depending of the area of the deposit being mined.

In the case of Libby amphibole asbestos, the mineral was originally called tremolite, soda-tremolite or sodium-rich tremolite by both mineralogists and the mining industry (Western News, 1927; Larsen and Pardee, 1929; Boettcher, 1966b; Bassett, 1959). In 1963, Deer, et al., described the Libby amphibole as richterite ("soda tremolite"). In the 1980s, it was referred to as tremolite (McDonald et al. 1986, 1988), and tremolite-actinolite (Amandus and Wheeler 1987).

When the Subcommittee on Amphiboles of the International Mineralogical Association finalized the classification parameters, the Libby amphiboles, after careful chemical analysis, were fit into chemically related zones and assigned the minerals winchite, richterite, tremolite, actinolite and possibly edenite. (Leake, et al., 1997). As a part of the tremolite series, actinolite, richterite and winchite are all amphiboles and are very similar to tremolite in shape, size and chemical composition. The only difference between tremolite and actinolite is the higher presence of iron (Fe) in actinolite. The only difference between tremolite and winchite is the presence of a small amount of sodium (Na) in richterite. The only difference between tremolite and richterite is the presence small amounts of sodium (NA) and potassium (K) in winchite. Interestingly, the change from one mineral to the next within the tremolite series has been observed within a single fiber. Distinguishing between tremolite, winchite and richterite using a polarized light microscope is difficult because the three minerals have very similar optical properties. Until recently, W.R. Grace always referred to the Libby amphibole asbestos as tremolite (Yang (W.R. Grace), 1976; Wood (W.R. Grace), 1977). In fact, Julie Yang, Grace's head microscopist, testified that in the thousands of asbestos samples she analyzed, she always referred to the asbestos as tremolite and testified that most of the asbestos from Libby is tremolite. (Deposition of Julie C. Yang Feb. 20, 2003). While use of electron microscopy may allow one to distinguish between tremolite, actinolite, winchite and richterite, accurate distinction between the four minerals is very difficult since the mineral chemistry can blend together and is generally beyond the capabilities of the standard routine methods in use today.

There is no evidence that OSHA ever intended to exclude the Libby amphibole from the regulations adopted in 1972. At the time the OSHA standard was enacted, Libby was regarded as containing tremolite and actinolite, two of the asbestos types specifically mentioned in the regulation. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund, does not limit the definition of asbestos to the commercial types. In fact, the Chemical Abstract Service (CAS) specifically includes winchite and richterite within the amphibole asbestos classification. There is general agreement that there is calcium amphibole asbestos in the Libby material, which EPA and other government agencies now generally refer to as Libby Amphibole Asbestos. As concluded by Ann Wylie (2000), these minerals regardless of their name should be considered asbestos and hazardous.

Notably, the tremolite series of asbestos found at Libby opens the door for linking contamination to Grace's products manufactured with Libby vermiculite. Further, it will help confirm asbestos exposure to Grace's Libby vermiculite products through the analysis of lung tissue. This was recently demonstrated by Dr. Robert S. Wright, et al.,

who analyzed the lung tissue of a person who died of asbestosis and whose only known exposure was working two summers at a plant in California that expanded Libby vermiculite. The lung tissue analysis found tremolite, actinolite, anthophyllite and chrysotile asbestos. Notably, the investigators found other asbestiform fibers in "the series of sodium-calcium magnesium silicates characteristic of the Libby vermiculite." See R. S. Wright, et al., "Fatal Asbestosis 50 Years after Brief High Intensity Exposure in a Vermiculite Expansion Plant," Am. J. Resp. and Critical Care Med. Vol. 165, at 1147 (2002). See also September 24, 1991 letter/report by Victor L. Rogoli, MD RE: Harris Jorgensen Lung Tissue Analysis Results Finding Tremolite/Actinolite from Environmental Exposure to Libby Vermiculite.

GENERAL CHARACTERISTICS OF ZAI

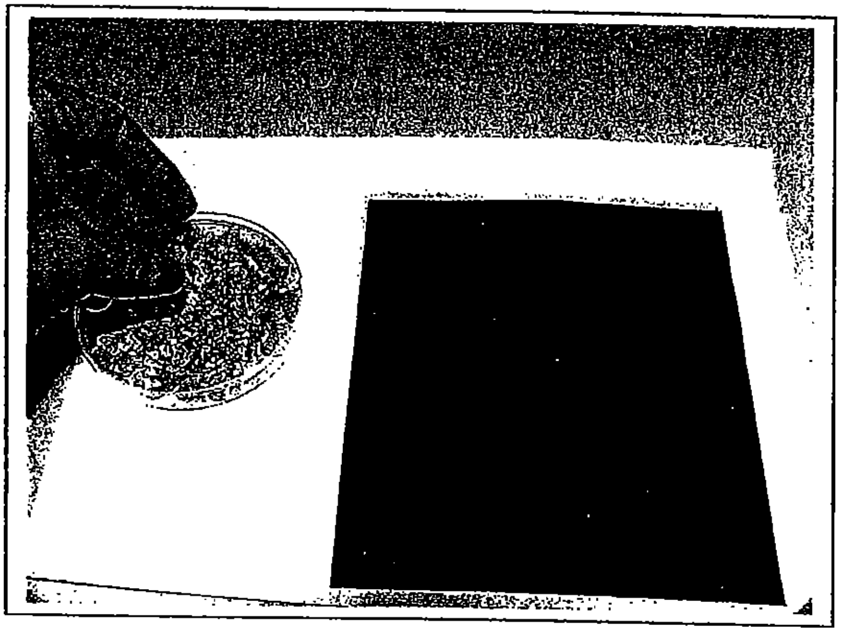
ZAI IS LOOSE AND FREE FLOWING

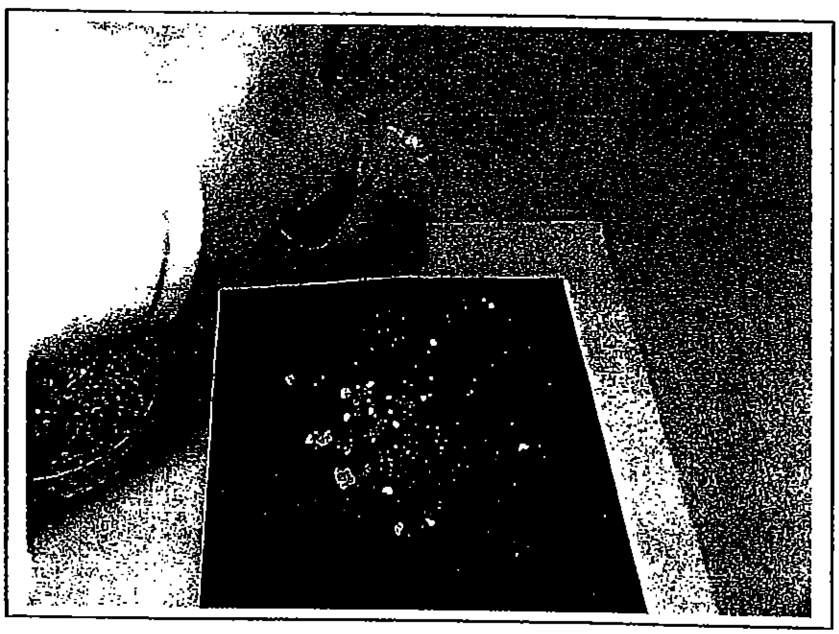
In order to evaluate ZAI and determine its asbestos content, MAS analyzed bulk samples of ZAI collected from homes and bulk samples collected from the original bags. ZAI is composed of expanded vermiculite, and is extremely dry, loose and free flowing in nature. The vermiculite granules move freely with gentle contact and readily tend to flow through small openings or gaps. This is consistent with Grace's advertisements, which touted its free flowing characteristics:

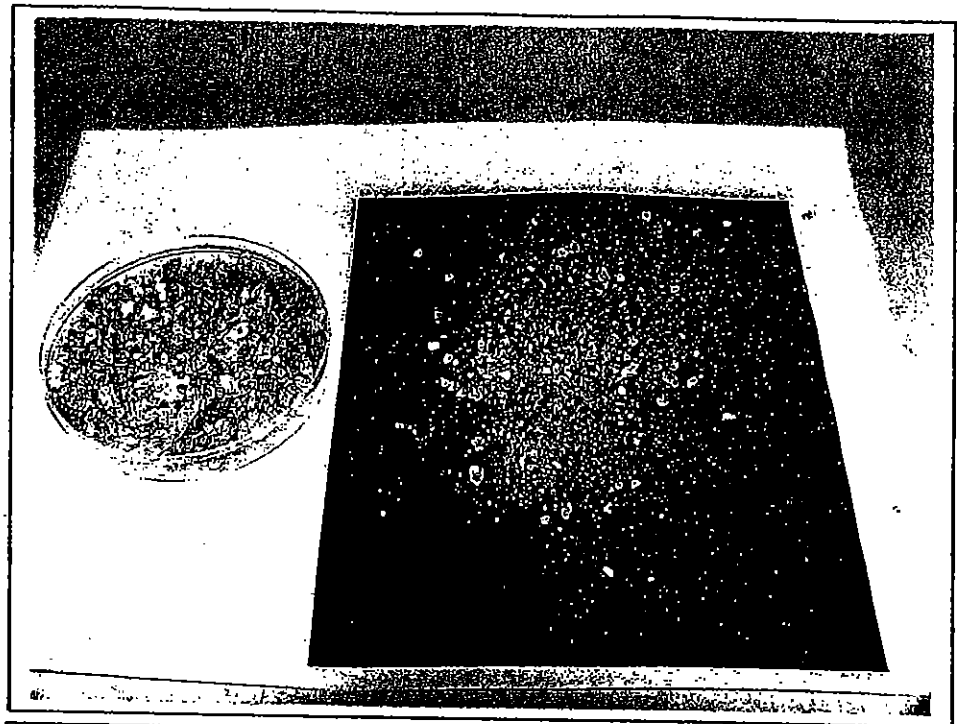
> Because of its free-flowing characteristics, Zonolite Attic Insulation easily fills up gaps around obstructions and existing insulation, thereby effectively sealing costly heat leaks. It is safe and ideal for the do-it-yourselfer to install.
>
> See ZAI Advertisement June 27, 1978 Insulation Gets and Assist from John Havlicek

FRIABILITY OF ZAI

The US EPA defines friability as a material's ability to be crushed by hand pressure. It is our opinion that the expanded vermiculite granules used for ZAI are highly friable and can be crushed with minimal force. This has been a consistent characteristic of ZAI since the mine opened, as shown by patent documents from 1928 for Libby expanded vermiculite which compared its friability to the ash end of a cigar. [US Patent Office Patent #1,693,015]. The following series of photographs demonstrate the ease with at which ZAI vermiculite granules can be crushed and release fibers.







NATURE OF ASBESTOS FOUND IN ZAI

Grace's Libby amphibole asbestos is highly friable and breaks apart with minimal force. This is reflected in Grace's own internal records. In our work, we have analyzed thousand of samples for asbestos and observed the friability of the materials. Having analyzed thousands of samples and observed their friability, it is our opinion that ZAI has one of the highest friability factors of any products containing asbestos.

MAS also evaluated the material for dustiness and found it to contain a certain amount of very fine loose asbestos containing dust that coats the vermiculite granules and readily becomes airborne when gently disturbed. This fine coating of asbestos dust is demonstrated in the following pictures:

The ease with which the material releases dust is evidenced by the simulations involving the scooping of ZAI, using the Tyndall beam effect. Moreover, the asbestos containing dust fibers also tend to sift down, which is evidenced by the concentration of the asbestos detected in the fine dust observed at the bottom of the in-place material. Dust sample #4 was collected from the fine dust under a pile of ZAI and resulted in a much higher amphibole asbestos content.

DUST SAMPLES COLLECTED FROM A HOME IN SILVER SPRINGS, MD

Dust samples (collected prior to cleaning)

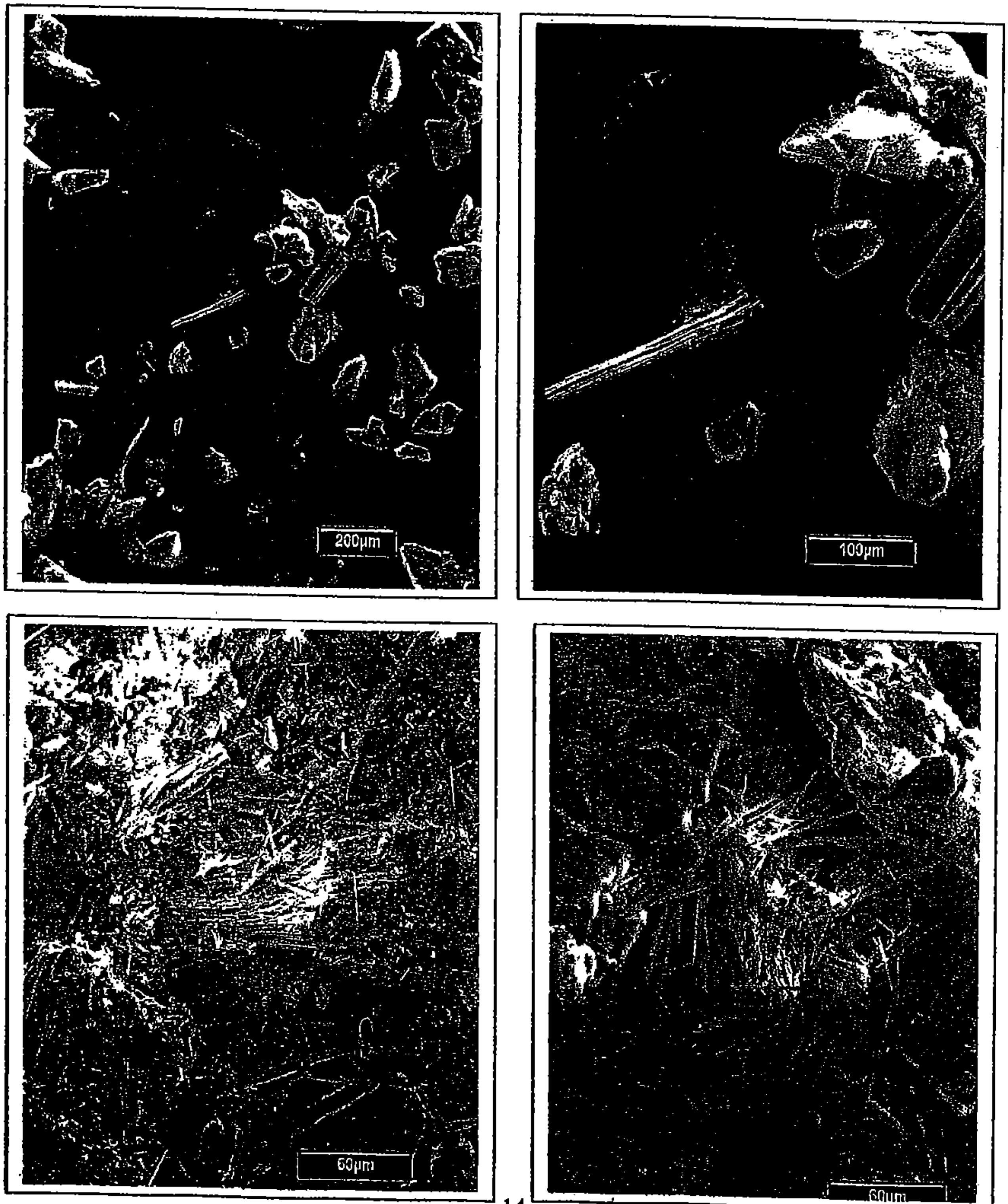
	Location	Asb. Str./ ft^2	Asb. Str. / cm^2
Dust 1	South end of attic from center walk board	92.2 Million	99.2 Thousand
Dust 2	North center of attic from walk board	31.8 Million	34.2 Thousand
Dust 3	Attic center top of access stairs from board	89.7 Million	96.6 Thousand
Dust 4	South end of attic collected from dust under pile of vermiculite on walk boards	**1.8 Billion**	**1.9 Million**
Dust 5	Blank	ND*	ND*

* None detected

Using an SEM microscope, MAS analyzed samples of ZAI collected from homes and collected directly from bags of ZAI left over in the homes. The asbestos in ZAI typically appears as respirable sized fibers and bundles greater than five microns in length. Further, The Libby amphibole asbestos fibers coat the vermiculite granules and are

associated with the fine dust that is free and loose within the material. Using increasing magnification, the following photographs show how the Libby amphibole asbestos fibers typically appear as a contaminant in the material.

As seen in the photograph below, the asbestos fibers are also found intertwined between the vermiculite layers. It is our opinion that these fibers can be released when the vermiculite is crushed or otherwise disturbed.



The appearance of the asbestos in ZAI is markedly different from the asbestos in products with commercially added asbestos, which are subject to strict regulations by EPA under the NESHAP regulations. Typically, products with commercially added asbestos were mixed with a gypsum, cement or clay base. For example, Grace manufactured on or before 1973 a product called Monokote MK-3, which contained approximately 12% commercially added chrysotile asbestos and 55 % gypsum. According to Grace, the gypsum acted as a binder to keep the asbestos fibers "locked-in" to the matrix. In contrast, ZAI, has no binder whatsoever to hold the asbestos fibers in place. As seen in the video demonstrations, the most gentle of contact will cause asbestos dust to be released into the air.

ASBESTOS CONTENT OF ZAI

Testing performed by or on behalf of Grace demonstrates that ZAI from its Libby mine always contained asbestos amphiboles as a contaminant. Grace's bulk testing, which was mainly performed after efforts were made by Grace at its Libby mine and at its plants to remove the asbestos from its products in the 1970s, shows the asbestos content of ZAI still ranged up to .8%. As confirmed by its chief microscopist, Grace was never able to completely remove the asbestos from its vermiculite products. (Deposition of Julie C. Yang, Feb 20, 2003)

By way of background, Grace's Libby vermiculite deposit contained as much as 40% amphibole asbestos. (Montana Health Department Report) The vermiculite deposits at Grace's Libby mine are mainly located in a mountain 4,200 feet high, called "Zonolite Mountain." As described in the 1962 issue of "Masonry" magazine, Grace used huge power shovels to extract the rocky material from Zonolite Mountain. The material was hauled to a primary plant at the edge of the deposit, where the larger rocks were removed. The smaller material was then transported to the mill, where it was blended and fed into a series of crushers, screens, and water floatation tables to remove rock and other foreign matter. The milled material was dried in large rotary kilns and screened into six closely graded sizes for various end uses. The grades ranged from 0 to 5, with 0 being the largest and 5 being the smallest in size. Grace used Libby 1, 2 and 3 grade ore for its ZAI product. W.R. Grace's chief microscopist, Dr. Julie Yang, reported in 1976 that, "From previous research work (report on Libby Ore Evaluation – Ore Impurities, 2/23/76) we have found that Libby #2 vermiculite product has the highest tremolite fiber content in the order of 5% by weight." According to McDonald (1986), "the vermiculite ore as fed to the mill contained 4-6% of amphibole fibre in the tremolite series."

The unexpanded raw vermiculite ore was shipped by rail to the various expanding plants around North America. At the plant, the material was fed into a furnace and heated to 2,000 degrees Fahrenheit. Some of the dust was separated out from

expanded vermiculite using a system of bag houses that collected the dust. This dust was known as cyclone fines. Notably, it was Grace's practice prior to the late 1970's/early 1980's to reintroduce the fines back into the product. (Deposition of Thomas Hamilton Feb. 25, 2002) This is important because the cyclone fines would have had a high content of free asbestos fibers.

Testing performed by laboratories across the United States demonstrates that the asbestos content of ZAI varies greatly from as low as a fraction of 1% to as much as 3%. This is not unexpected because the raw ore from Libby also varied in asbestos content. Below is a list of results seen by various outside laboratories, all of which are certified under NAVLAP:

BULK SAMPLE ANALYSIS OF ZAI

Location	PLM Results	TEM Results
Lebal's Home	3%	
DeBock Home	2.70%	
Cohen Home	Trace	2.73%
Russ Home	2%	
McMurchie Home	1 to 3%	
MAS samples	<1%	

Based on our evaluation of ZAI, it is our opinion that the material is contaminated with varying concentrations of Libby amphibole asbestos fibers. It is also our opinion that the majority of asbestos fibers appear as free individual fibers, fiber bundles and clusters of fibers longer than 5 µm in length. It is also our opinion that the asbestos fibers can be released from the product with relatively little disturbance. Because of ease with which asbestos fibers can be released from ZAI, it is our opinion that the asbestos content by weight percent does not adequately assess the potential for the product to release airborne asbestos and cause exposure and contamination in areas within the home. Instead, the true indicia of exposure and contamination potential is through: 1) the appearance and number of asbestos fibers in a given amount of ZAI; 2) surface dust testing on surfaces in the vicinity of the ZAI; and 3) air testing during ordinary and foreseeable activities that disturb the material.

NUMBER OF ASBESTOS FIBERS IN ZAI

Due to the microscopic size of asbestos fibers, ZAI can contain billions of asbestos fibers in a given amount of material and still be barely detectable by weight percent measurements. Grace's corporate counsel recognized this when he recommended against disclosing the amount of asbestos by weight percent in Grace's MSDS documents regarding certain vermiculite products, and stated:

> I understand that the reason for wanting to indicate the percent by weight of tremolite content is to give the recipient the indication that he is not getting a product containing commercial asbestos and that the tremolite asbestos contaminate content is low. However, I think that this could be construed as an invitation for the recipient to believe that because the percent tremolite asbestos content is low that the amount of tremolite asbestos fiber released in handling the product can be assumed to be less than this prescribed by the asbestos standard. As you know, respirable asbestos fibers are light and countless numbers maybe present ever though the percent by weight is low.
>
> Notes attached to April 7, 1977 memo from R. C. Ericson, regarding 2nd Draft Proposal for MSDS for Vermiculite Concentrate & Finished Product.

Based on the size range of fibers typically found in ZAI, one can calculate the number of asbestos fibers in a given weight of the material and at a given weight percentage of asbestos. These figures, which are set forth below, show that even at a fraction of 1% asbestos, there are a significant number of asbestos fibers present in ZAI. Using the typical dimensions of a Libby amphibole fiber of 5.0 microns long and 0.2 microns wide, that fiber will weigh approximately 0.000471 nanograms (ng). Assuming a bag of ZAI weighs 13 lbs, then the following Table shows the total number of amphibole fibers if the ZAI bag contains 0.001%, 0.01%, 0.1%, 1.0% and 3.0% by weight of the asbestos contaminate.

		Weight of Amphibole in Bag	Number of Fibers in Bag
1)	0.001	0.059 grams	125,310,000,000
2)	0.01%	0.59 grams	1,253,100,000,000
3)	0.1%	5.90 grams	12,531,000,000,000
4)	1.0%	59.0 grams	125,310,000,000,000
5)	3.0%	177.1 grams	375,920,000,000,000

ASBESTOS SURFACE DUST CONTAMINATION

Based on our experience, the use of ambient (quiescent) air sampling is an inadequate technique to determine if in-place materials can release asbestos fibers into the air and cause surface/building contamination. As recognized by EPA, air sampling is only a "snap shot" in time and will likely miss a release episode of asbestos structures from the in-place ACM.[1] Instead, the best way to determine the propensity for materials to release asbestos and cause surface/building contamination is through air testing during ordinary and foreseeable activities that can disturb the material. Further, the best way to determine whether asbestos fibers have been released as a result of past disturbance activities and have caused surface/building contamination is by sampling

[1] EPA 20T-2003 (Green Book P. 14); EPA 560/5-85-024 (Purple Book p. 403); EPA OTS C0090 (Orange Book Part I, p. 14).

and analyzing the settled dust. In general, experts perform asbestos dust testing routinely for private, industry and the government clients.

ASSESSMENT OF SURFACE CONTAMINATION

Certain surface concentrations of asbestos structures have been deemed contaminated in the opinion of recognized experts and governmental agencies taking into account a background level of chrysotile asbestos in the environment.[2] Because chrysotile is found in some urban environments, most experts consider up to one thousand structures of chrysotile asbestos per square centimeters to reflect background levels of asbestos deposition that may now be related to from a particular source. Because there is no background level of tremolite in the general environment, any surface dust (or dust in the air) containing tremolite asbestos would be considered to be contaminated.

As discussed below, the most widely used and accepted method for assessing surface dust for asbestos is the ASTM method D-5755-95 entitled "Micro-Vacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Concentration". This method was published by the ASTM in 1996 and has the advantage over ambient air sampling since it can measure the amount of asbestos that has accumulated over time on a surface, and in many instances (such as this case), provide information about the source of the contamination.

THE ASTM MICROVACUUM METHOD WAS APPROVED FOLLOWING A RIGOROUS SCIENTIFIC PEER REVIEW PROCESS

The ASTM microvacuum method is a standardized analytical method that was subjected to a rigorous scientific peer review process involving hundreds of scientists over a period of six years. The procedures of the ASTM committees require a unanimous vote from the entire membership to approve a new method.

THE STANDARDIZED PROCEDURES UNDER THE ASTM MICROVACUUM PROTOCOL

Following the ASTM microvacuum method, loose dust is vacuumed from a given surface area using a modified air sampling cassette with a standard MCE filter air cassette. The cassettes/filters are sent to the laboratory for preparation and analysis. Following the ASTM microvac method, the filter is rinsed with a specified amount of water/alcohol solution and the mixture is gently sonicated in a beaker to evenly distribute the fibers within the mixture. A specified amount of the mixture is drawn from

[2] Millette, J.R. and Hayes, "Settled Asbestos Dust Sampling and Analysis", and Hatfield, R.L. "Settled Dust Sampling and Analysis", (unpublished manuscript).

the beaker and re-filtered onto another filter. The filter is then analyzed by TEM and the asbestos concentration is determined.[3]

USE OF INDIRECT METHOD IS SUPERIOR TO THE DIRECT METHOD FOR ANALYZING DUSTY ENVIRONMENTS

Sampling of air and surface dust with significant concentrations of asbestos dust and/or other non-asbestos dust will result in heavily loaded filters. This is a typical problem with almost all dusty surfaces. The overloading of dust on filters prevents the microscopist from seeing and identifying the asbestos fibers when the filters are prepared using the direct method. Without diluting and dispersing the asbestos fibers evenly on the filter, it is impossible to quantify the number of asbestos fibers in the dust. Because of the general nature of surface dust, the filters are generally too overloaded with dust to allow the individual asbestos fibers to be seen using a direct preparation method

As stated above, dust samples are too loaded to effectively identify and quantify the asbestos because of the obscuration effect of the dust. This problem was solved by the development of the ASTM D-5755-95 dust testing protocol, which dilutes and disperses the asbestos fibers onto a filter. [(3)] This method allows heavily loaded samples (such as dust samples), to be analyzed without affecting the integrity of the results.

Notably, Grace itself has recognized the need for using the indirect method. In 1988, Grace submitted to MAS air samples for analysis and requested they be analyzed by the indirect method in the event that any of the samples were overloaded. (See June 2, 1988 letter from David J. Curreri to MAS.)

ASTM MICROVACUUM METHOD MEETS ACCEPTED PRECISION STANDARDS

Precision data for ASTM D5755 has now been developed and presented to Subcommittee D-22.07 for consideration (the "Precision Data"). The Precision Data shows that based on the inter-laboratory rounds with at least 6 independent laboratories (not including the laboratory that made up the samples), the coefficient of variation ("CV") (the standard deviation divided by the mean value) for ASTM D5755 appears to be around 0.6 – 0.8. The Precision Data is in agreement with the data from an earlier study that we co-authored in which the results of a round robin study of an earlier version of the microvac technique showed a coefficient of variation of 0.73.[4] It is also similar to the intra-laboratory precision data for microvac technique of 0.77 that was published in the USEPA Report EPA/600/J-93/169.

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[3] ASTM D-5755-95 (1995).

[4] See Hatfield, Krewer and Longo, *A Study of the Reproducibility of the Micro-Vac Technique as a Tool for the Assessment of Surface Contamination in Buildings with Asbestos-Containing Materials*, in Advances in Environmental Measurement Methods for Asbestos, ASTM STP 1342, (Michael E. Beard and Harry L. Rook, Eds. 1999).

The Precision Data also falls within the inter-laboratory CV range for the light microscope phase contrast fiber counting method, NIOSH 7400 A rules, which is listed as 0.27 to 0.85. In fact, it is lower (i.e., more precise) than the CV value of 1.5 reported by Yamate[5] for the EPA TEM air measurement of asbestos sample preparation with the direct method.[6]

The Precision Data is also in keeping with a recent study of settled dust analyzed in the Crankshaw Study [8], which found that the intersample variability for the D5755-95 method, including sample collection, was typically less than + or – 15% (CV=. 15). Crankshaw also reported:

> Results from the microvacuum structure count samples indicate that the method adequately tracks the concentration of asbestos in the dust and that the variability is quite low. When the concentration of asbestos was increased ten-fold, as from 0.1% to 1% or from 1% to 10%, the number of structures per area increased proportionately.

THE ASTM MICROVACUUM METHOD IS GENERALLY ACCEPTED

Notably, other experts in the field use the ASTM Microvacuum method to identify and evaluate asbestos in surface dust. This method was used by EPA to evaluate asbestos dust in homes in Libby, Montana. This method was also used by EPA to evaluate documents produced by Grace for possible asbestos contamination. The dust sample results demonstrated the documents to be contaminated with asbestos, prompting EPA to instruct that persons who had worked with the documents be notified and appropriate safety precautions be taken to prevent any additional exposures to asbestos.

Based on our experience, training and analytical work, the results obtained from the indirect number count microvacuum method is accepted in the industry for assessing contamination and determining the source of the contamination. Further, the indirect number count microvacuum method is an accurate and precise representation of the loosely associated asbestos present on the surface.[7] Our experience has shown that the indirect sample preparation process does not substantially alter or change the form of the dust particulates that are sampled. That is, the asbestos structures observed in the electron microscope from the dust samples are representative of the type and number of asbestos structures actually released from the surrounding materials containing asbestos and that have settled on otherwise uncontaminated surfaces.

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[5] See G. Yamate, S.C. Agarval and R.D. Gibbons, Draft Report, Washington, D.C.: Office of Research and Development, USEPA Contract No. 68-02-3255 (1984).

[6] Crankshaw, Perkins and Beard, *An Overview of Settled Dust Analytical Methods and their Relative Effectiveness* (the "Crankshaw Study"), in Advances in Environmental Measurement Methods for Asbestos. ASTM STP 1342 (Michael E. Beard and Harry L. Rook, Eds., 1999).

[7] Crankshaw, Owens, Research Triangle Institute "Quantitative Evaluation of the Relative Effectiveness of Various Methods for the Analysis of Asbestos in Settled Dust" (1995). And MAS unpublished Round Robin dust data.

Other generally accepted analytical methods also use the indirect method. See, e.g., ISO 13794, method, entitled, "Ambient Air – Determination of Asbestos Fibres – Indirect-transfer Transmission Electron Microscopy Procedure." International Standards Organization, 1999. (TEM); "Superfund Method for the Determination of Releasable Asbestos in Soils and Bulk Materials" (Interim Version), Berman, D. W. and Kolk, A., Prepared for US. EPA Region 9, San Francisco, CA, Contract number: 68-w9-0059, July 1995 (TEM). Also, additional methods requiring indirect preparation methods are currently being developed or used by US EPA and US Geological Survey (USGS), as well as ASTM.

THE USE OF THE INDIRECT METHOD IS PARTICULARLY APPROPRIATE FOR ZAI ANALYSIS

The use of sonication to homogenize the dust suspension during the preparation of air and dust samples for analysis by TEM has been subjected to criticisms by some in recent years, mainly by experts paid by the asbestos industry. The concerns have mainly been the claims that sonication breaks up bundles, clusters and matrices composed of particulates of asbestos and non-asbestos materials, such as gypsum or clay. The critics contend that this results in counts of asbestos fibers that would not ordinarily be inhaled. This criticism is inapplicable regarding asbestos air and dust samples, especially for ZAI, because the majority of the asbestos found in the dust is individual respirable sized fibers and fiber bundles. As discussed below, the asbestos fiber count using the indirect method is designed to be more precise by providing a more homogenous and optimum sample for analysis. The indirectly prepared sample will better reflect the number of individual asbestos fibrous structures in the surface dust or in the air.

Notably, the airborne levels found in two studies involving the similar disturbance of ZAI in the Barbanti and Busch homes resulted in very similar airborne concentrations (the same order of magnitude), despite the fact that one set of air samples was prepared using the indirect method of analysis while the other set was prepared using the direct method. This demonstrates that the indirect preparation method does not alter the asbestos structures and validates using the indirect method for dust and air samples involving ZAI.

RESULTS OF DUST TESTING IN HOMES WITH ZAI

Dust samples were collected from various homes with ZAI and the results are set forth below:

DUST SAMPLE RESULTS FROM VARIOUS HOMES

Sample Locations	Asb. Str./ft^2	Asb. Str/cm^2
Mason Home (Libby)		
Floor of Atticapartment storage area	32.7 million	35.2 thousand
From unused rolled sheet metal in attic	10.2 million	10.9 thousand
Spencer Home (Libby)		
light dust from children's bedroom closet	399.7 thousand	430.3 hundred
medium dust from child's game in closet	6.4 million	6.9 thousand
heavy dust from shelf support in closet	17.3 million	18.6 thousand
Walker Home		
walk boards in attic	41.1 million	44.2 thousand
wooden steps of attic access ladder	22.8 million	24.6 thousand
Loehner Home		
dust on attic floor near stair case	195.6 million	210.5 thousand
dust from attic flooring in attic wing	13.9 million	14.9 thousand
Salibury Home (Moscow, Idaho)		
Daughter's bedroom closet off cabinet glass door	37.4 million	40.2 thousand
Daughter's bedroom closet off the floor	6.2 million	6.7 thousand
Dust from carpet in office closet	5.2 million	5.6 thousand
Matthews Home (Spokane, WA)		
Attic Floor (ZAI in perimeter only)	24.9 million	26.9 thousand
Carpet on attic floor (ZAI in perimeter only)	2.8 million	3.0 thousand
on wooden storage box in attic (ZAI in perimeter only)	none detected	none detected
Home Silver Spring, MD		
South end of attic off walk boards	92.2 million	99.2 thousand
North center from walk boards	31.8 million	34.2 thousand
Attic center off board at access stairs	89.7 million	96.6 thousand
South end of attic dust under vermiculite pile on walk boards	1.8 billion	1.9 million

DUST SAMPLE RESULTS FROM VARIOUS HOMES
Continued

Sample Locations	Asb. Str./ft^2	Asb. Str/cm^2
Barbanti Home (Spokane, WA)		
Dust from under vermiculite	46.8 million	50.3 thousand
Dillion Home		
Attic surfaces after home removal 1	943.6 million	1.0 million
Attic surfaces after home removal 2	741.7 million	798.4 thousand
Attic surfaces after home removal 3	150.7 million	162.2 thousand
Attic surfaces after home removal 4	45.4 million	48.8 thousand
Attic surfaces after home removal 5	32.4 million	34.8 thousand
Attic surfaces after home removal 6	10.3 million	111.0 thousand
MacCready Home		
Attic dust under ZAI 1	561.2 million	604.1 thousand
Attic dust under ZAI 2	845.6 million	910.2 thousand
Bush Home		
BD-01	47.2 million	50.8 thousand
BD-02	ND	ND
BD-3	191.0 million	205.6 thousand
Matthews Home		
MD- 1	6.3 million	6.7 thousand
MD- 2	35.4 million	38.1 thousand
MD- 3	ND	ND
MD- 4	18.5 million	20.0 thousand
MD- 5	ND	ND
MD- 6	ND	ND
MD- 7	ND	ND
MD- 8	ND	ND
MD- 9	ND	ND
MD- 10	ND	ND
MD- 11	626.3 thousand	0.7 thousand
MD- 12	309.1 thousand	0.3 thousand
MD- 13		
MD- 14		
Price Home		
Garage above stairwell to basement	ND	ND
Garage off door mat	ND	ND
Kitchen off door mat to garage	ND	ND
Garage from intake for fireplace	ND	ND
Holbrook Home		
Attic off joist	280.6 million	302.0 thousand
Attic top of chest	ND	ND
Attic dust from hand railing around staircase	821.2 thousand	0.9 thousand

ND = None Detected

The field blank samples when analyzed by the microvac method were shown not to contain any detectable asbestos. Dust samples from buildings that do not have asbestos products do not show any tremolite asbestos contamination such as that present in homes with ZAI.[8] In our opinion, the source of the asbestos contamination in the dust samples collected in these homes was the ZAI located in those areas. As discussed below, the actual disturbance of ZAI and dust from ZAI will cause the release of asbestos structures.

USE OF STUDIES TO ASSESS MATERIALS WITH ASBESTOS & PREDICT AIRBORNE CONCENTRATIONS <u>DURING ORDINARY & FORESEEABLE ACTIVITIES</u>

MAS analyzed airborne asbestos samples collected during simulated disturbance of ZAI in homes.[9] In the Barbanti home, the samples were analyzed by TEM. Because the filters were too overloaded to be analyzed using direct preparation, they were analyzed by TEM using the indirect method. Knowing the overloading problem encountered in the testing performed in the Barbanti home, we adjusted the sampling volumes for the testing performed in the more recent simulations. By minimizing the air volumes, we were able to minimize the overloading. Therefore, we were able to use the direct method to prepare the samples for analysis by both PCM and TEM. The results of our studies are contained in the report summarized in Mr. William Ewing's materials.

Based on our evaluation of ZAI and the results of the simulation testing, it is our opinion that this material will release asbestos fibers into the air when the material is disturbed during ordinary and foreseeable disturbance activities. Additionally, the amounts of asbestos fibers released during upon disturbance of ZAI are significantly higher than over measured background levels. Additionally, in our opinion, the release of asbestos from ZAI causes contamination on surrounding surfaces in homes containing ZAI. The disturbance of ZAI by ordinary activities of homeowners and contractors, including maintenance, repairs, and demolition, will cause the release of airborne asbestos from the material exposing families to significant levels of asbestos.

We have reviewed air testing performed by Grace in connection with the use of ZAI. The testing included actual and simulated installation of ZAI, including the spreading of the material. At times, the samples were analyzed by PCM, using a method of "discriminatory counting" that eliminated from the results objects that would have normally counted as fibers by the standard OSHA/NIOSH method. In our opinion, the airborne concentrations detected and reported by Grace using their discriminatory analysis method may have resulted in under estimates of the true airborne asbestos concentrations. Notably, some of the early testing involved production ZAI from the plant. It is our opinion that Grace's testing using production ZAI demonstrated the propensity of the product to release asbestos into the air during ordinary use, and confirms that disturbance of ZAI results in elevated airborne fibers to significant levels.

[8] MAS reports October 14, 1992 (M-9317), February 10, 1992 (M-7883), September, 1992 (M-9132) and April 6, 1992 (M-8168).

[9] MAS May 18, 1991 Kaylo Study.

Notably, many of the airborne fiber levels found during the pouring and spreading of the material were very similar to the levels found in our studies. Many of Grace's subsequent tests in actual attics during installation involved the use of experimental materials, including so-called "super clean" ZAI. Even with "super clean" in which Grace attempted to remove as much as possible of the asbestos, the material released significant amounts of asbestos fibers into the air when being poured and spread out.

RECENT CLEANING STUDY

During a recent study involving cleaning of walk and storage boards located in an attic insulated with ZAI, results indicate that persons conducting the cleaning (broom sweeping) are exposed to levels in excess of the current OSHA standards. The chart below illustrates the exposures.

ZONOLITE ATTIC INSULATION
CLEANING STUDY – SILVER SPRING, MD

SAMPLE LOCATION		PCM	TEM (All)	TEM (>5μm)
	Background			
B-1	Southside (Attic)		<0.003	N/A
B-2	Center (Attic)		<0.004	N/A
B-3	Northside (Attic)		<0.005	N/A
B-4	Entrance to Master Bedroom (1st Floor)		<0.005	N/A
B-5	Entrance to Master Bedroom (1st Floor) (During Cleaning)		<0.005	N/A
	During Cleaning - Personnel			
Worker				
W-8-1		2.900		
W-8-2		2.708		
W-8-3		3.000		
W-45-1			5.069	2.535
W-45-2			4.464	2.551
W-45-3			2.464	2.464
Helper				
H-8-1		<0.539	<0.673	N/A
H-8-2		0.643	0.499	0.499
H-8-3		1.050	0.657	0.657
H-45-1			<0.762	N/A
H-45-2			<0.608	N/A
H-45-3			<0.781	N/A

ZONOLITE ATTIC INSULATION
CLEANING STUDY – SILVER SPRING, MD
CONTINUED

SAMPLE LOCATION		PCM	TEM (All)	TEM (>5µm)
During Cleaning - Area				
1-1			1.356	0.839
1-2			1.058	0.747
1-3			0.237	0.237
2-1			0.234	0.176
2-2			1.265	0.783
2-3			0.343	0.343
3-1			<0.063	N/A
3-2			0.672	0.403
3-3			0.457	0.196
Dust samples (collected prior to cleaning)				
Location			**Asb. Str./ sq. ft.**	**Asb. Str./ sq.cm.**
Dust 1	South end of attic from center walk board		92.2 Million	99.2 Thousand
Dust 2	North center of attic from walk board		31.8 Million	34.2 Thousand
Dust 3	Attic center top of access stairs from board		89.7 Million	96.6 Thousand
Dust 4	South end of attic collected from dust under pile of vermiculite		1.8 Billion	1.9 Million
Dust 5	Blank * None detected		ND*	ND*

In addition to our own research and studies of asbestos, our opinions and testimony are based on the research and studies of other scientists and governmental bodies. A list of reliance materials on which we may rely to form the basis of our opinions is attached and incorporated by reference; however, we may also rely in whole or in part on the publications as well as opinions, data and materials produced in discovery, or contained in the reports of other experts which the plaintiffs or the defendant designates in this action. We also reserve the right to rely on any scientific articles or studies subsequently presented or published. We have prepared this report in accordance with Rule 26(a) (2) of the Federal Rules of Civil Procedure.

Dr. William Longo — Date: 4/4/03

Richard L. Hatfield — Date: 4/4/03